

TB MED 194

WAR DEPARTMENT TECHNICAL BULLETIN

**DDT
INSECTICIDES
AND THEIR
USES**

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TB MED 194, DDT Insecticides and Their Uses, is published for the information and guidance of all concerned.

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Refer to FM 21-6 for explanation of distribution formula.

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This bulletin follows TB MED 193, subject, "Poliomyelitis." Distribution given TB MED 193 was identical with that given TB MED 142.

1. INTRODUCTION. *a.* The advent of DDT has provided an extraordinary potent chemical for insecticidal uses. Laboratory experiments and field trials have demonstrated the wide range of application of DDT in a variety of forms for the control of disease-bearing and pest insects. Some variation exists in toxicity for different types of insects. Much remains to be learned before the full potentialities of DDT in insect control can be realized. Investigations are continuing on every aspect of DDT, from its chemistry and manufacture to the development of new and refined methods of dispersal.

b. The DDT insecticides adopted by the Army are listed in WD Circular 163, 1945, and in ASF Catalog QM 4 (Quartermaster Supply Catalog), January 1945, which give the basis of issue and allowances. Production of DDT is sufficient to meet all military requirements and it is urged that this insecticide be used to maximum advantage in the control of insects affecting the health and well-being of troops.

a. Since the proper use of DDT requires special knowledge and training, this bulletin is published as a technical guide to its efficient, safe, and economical use. Information in this bulletin supplements that already published in TB MED 14, 82, 87, 110, 119, 124, 134, 138, 142, 144, 159, 164, 181, 182, 183, and 184.

2. CHEMICAL AND PHYSICAL CHARACTERISTICS. *a. Definition.* DDT (Dichloro-Diphenyl-Trichloroethane) is a white, crystalline, synthetic substance resulting from the reaction between monochlorobenzene and chloral hydrate, or chloral. It has the following chemical formula: 2,2-bis (p-chlorophenyl)-1,1,1-trichloroethane. DDT is the official name adopted by the United States and British armed forces for this new synthetic insecticide. It also has been referred to in various publications as Gesarol, Neocid, GNB, GNB-A, and SBLV.

b. General properties. In chemically pure form DDT has a melting point of 107° to 108° C. The technical product melts at a lower temperature. Present specifications call for a setting

point of 89° C. or above. The specific gravity of the substance is approximately 1.6. The technical product is a fine powder varying from white to yellowish white in color. It is remarkably stable under field conditions. When exposed to relatively high humidity, technical DDT has a tendency to agglomerate, forming lumps of various sizes, but this does not affect its insecticidal efficiency. Exposure to sunlight or storage for long periods of time at the high temperatures prevailing in the Tropics or in cargo holds apparently causes no deterioration. Data on solubility are contained in *c* below. DDT lends itself well to dispersal in a variety of forms—in oil solutions, in emulsions, in suspensions, or in powder form diluted with inert vehicles.

c. Solubility (1) *General*. DDT is practically insoluble in water, moderately soluble in mineral and vegetable oils, and readily soluble in many common organic solvents. It is more soluble at higher temperatures than at lower ones. Its solubility in impure petroleum oils will be found to vary with the lot of oil. By the use of suitable solvents, concentrated DDT oil solutions, emulsions, or suspensions can be prepared.

(2) *Table of solubility.*

SOLUBILITY OF DDT IN COMMON ORGANIC SOLVENTS (APPROXIMATE)

Solvent	Grams per 100 cc. of solvent at 27°-30° C.	Ounces (avoirdupois) per quart of solvent at 80°-86° F.
Mineral oils:		
Fuel oil No. 2.....	10	3.4
Fuel oil No. 1.....	8	2.7
Kerosene (crude).....	8	2.7
Kerosene (refined, odorless).....	4	1.3
Vegetable oils:		
Soybean oil.....	14	4.7
Tung oil.....	12	4.0
Sesame oil.....	10	3.4
Cottonseed oil.....	9	3.0
Castor oil.....	7	2.4
Other solvents:		
Cyclohexanone.....	100	33.6
Xylene.....	56	18.8
Acetone.....	50	16.8
Ether.....	27	9.1
Ethyl alcohol (95 percent).....	1.5	.5

3. MODE OF ACTION. *a. Dual action.* The action of DDT on insects is unique, in that it is both a contact poison and a stomach poison. The toxic effect from either contact or ingestion is apparently exerted principally on the nervous system of the insect. Insects at first display hyperactivity and tremors, followed by progressive paralysis of their locomotor appendages and death.

b. Residual effect. DDT has insecticidal properties of prolonged duration. For several weeks or even months after original application in the form of a spray or powder the deposit will kill insects which rest on or crawl over the treated areas. The extraordinary value of DDT lies in this residual effect. Absorption of DDT sufficient to cause death apparently takes place through the legs, wings, or other parts of insects when in contact with treated surfaces for even short periods of time. In some instances it may take several hours for the insects to die and in the meantime they may have hidden or escaped outdoors. Hence, the number of dead insects found at the treated site should not be accepted as the sole criterion for the efficacy of the treatment.

c. Action on mosquito larvae. Laboratory studies on the larvae of anopheline mosquitoes indicate that the toxic effect of DDT is exerted on mosquito larvae much the same as on adult insects. The first symptom of DDT poisoning is excessive swimming along the surface and occasional tremors. Then contact with the surface is lost and the larvae sink. Repeated attempts are made to regain the surface but with each effort the larvae become weaker and the height attained correspondingly decreases until they are no longer able to rise. Tremors are frequent and violent and death occurs after several hours. Because anopheline larvae rest parallel to the surface and are also surface feeders, they may be more quickly affected by a given concentration of DDT than are culicine larvae, the opportunity for contact and ingestion being greater.

4. TOXICITY AND PRECAUTIONS. *a. General.* It should be emphasized that, although DDT can be handled safely, it is nevertheless a toxic material. Poisoning may occur from ingestion of DDT or by absorption of DDT

solutions through the skin. Personnel should be trained thoroughly in safe methods of application of the DDT insecticides and should not disregard the recommended precautions.

b. Toxicity, symptoms and findings. (1) Symptoms of DDT poisoning in *laboratory animals* are loss of appetite, hyperexcitability, tremor, and convulsions. Dysfunction of the liver and kidneys may precede the onset of nervous system manifestations. When tremors first appear in animals poisoned by DDT, they are coarse in nature, involve the entire musculature, and are particularly marked in the legs upon standing and in the muscles over the eyes. The tremors decrease when DDT is withdrawn. Animals given DDT until a fatal termination frequently show a toxic necrosis of the liver and kidneys. Other organs are essentially negative.

(2) Toxicity for man must be deduced from these animal experiments. One case of DDT toxicity in man has been reported in the English medical literature but disagreement exists among toxicologists as to whether the symptoms observed were actually due to DDT. Three individuals who had been exposed for a long time to large amounts of DDT in the course of their work were carefully examined and observed for an extended period, to note any variations from the normal. Repeated physical, neurological, and laboratory examinations revealed no symptoms or signs of untoward effect from their exposure to DDT. While these findings are not considered conclusive, they do perhaps indicate a high degree of tolerance of human beings for DDT.

(3) Any individual using DDT insecticides in the field and suspected of displaying toxic effect from DDT should be removed from further contact with the insecticide and be placed in a hospital with adequate facilities for making a careful and complete examination, including neurological examinations and repeated liver and kidney function tests.

c. DDT in powders and dusts. (1) Dry DDT in concentrated form or when used mixed with inert powders is not absorbed through the skin. Experience based on large-scale industrial production and wide use in the field, indicates that the possibility of dermatitis due to contact with DDT powder is remote. Slight inhalation of

10 percent DDT powder as normally used in the field will not produce toxic effects. Nonetheless, it is wise for operators engaged in mass delousing or large-scale dust larviciding to use suitable respirators under conditions where air currents do not carry the dust cloud away from them.

(2) Care to prevent contamination of food and possible poisoning of humans from accidental ingestion of DDT must be taken because DDT is a white, odorless and tasteless powder bearing a physical resemblance to flour, and offers no warning upon ingestion. All food-stuffs, cooking utensils, eating utensils, and tabletops must be covered when dispensing DDT in any form in mess halls. Storage of DDT with food should be strictly prohibited. No information is available concerning toxic doses of DDT for man.

d. DDT in oils and organic solvents. Since solutions of DDT in oils and organic solvents can be absorbed through the skin, contamination of the garments and of the skin must be avoided. Coveralls and suitable solvent-resistant rubber or rubberized gloves should be worn when mixing such solutions. Occasional contact is apparently not dangerous, but prolonged contact might be harmful. When individuals accidentally contaminate themselves, they should change their clothes as soon as practicable and wash thoroughly with soap and water. In dispensing oil solutions, sprayers should be checked for leaks and should not be filled to more than three-quarters of their capacity, in order to reduce the chance of spilling. Continued inhalation of oil or kerosene sprays containing 5 percent or more of DDT may produce toxic effects, since absorption of DDT from the respiratory tract is facilitated by such solvents. While dispensing DDT sprays of 5 percent or more concentration indoors for prolonged periods, suitable respirators should be worn by the operators. By mouth, DDT preparations in oils and organic solvents exert considerably greater toxic effect than in powder form. Hence operators should take precautions similar to those prescribed in dispensing DDT as a powder, to prevent contamination of food when spraying in mess halls.

e. DDT in aerosols. The concentration of DDT in the atmosphere when dispensed with

the Insecticide aerosol dispenser (see par. 14) according to instructions (4 seconds of spraying per 1,000 cubic feet) is exceedingly small and can be breathed under normal conditions of use without ill effect. The 3 percent DDT aerosol formula will produce a concentration of approximately 0.06 mg of DDT per cubic foot when used at the recommended dosage. Daily exposure of human subjects for 1 hour to a concentration of 1.0 mg of DDT per cubic foot showed that the 3 percent DDT aerosol offers no health hazard under normal conditions of use.

f. DDT in emulsions. (1) Underwear impregnated with a DDT emulsion prepared from Insecticide, DDT, emulsion concentrate, has been worn in field tests for periods of from 1 to 4 months without toxic effect or irritation of the skin. Personnel engaged in impregnating underwear with DDT emulsions in the field should avoid dipping their arms in the prepared solutions or handling the wet garments with bare hands when wringing them out and hanging them up to dry. Ladles or tongs should be provided for immersing the underwear, and operators should wear neoprene gloves.

(2) Toxicity studies have shown that the 1 percent DDT emulsion, prepared from Insecticide, DDT, spray, delousing, by diluting with 5 parts water, is safe to apply to the skin. However, the preparation may be toxic if taken internally. No special precautions are necessary in mixing the stock solution or in dispensing the finished spray outdoors, but when this material is sprayed for long periods indoors, good ventilation and frequent rotation of operating personnel is recommended.

5. THERAPEUTIC AGENTS. *a.* The treatment of DDT poisoning is purely symptomatic and can only be based upon experience gained in treating laboratory animals. The actions of DDT on the nervous system are on a functional rather than an organic basis and their symptomatic control apparently results in recovery with no residual neurological lesion. In rats, the only species which has been extensively studied to date, the convulsions induced by DDT can best be controlled by the administration of urethane. In view of the fact that this agent is not very effective in humans, other central nervous system depressants should be employed.

To date no data are available to indicate any preference among such agents for the symptomatic control of DDT convulsions. In view of the fact that convulsions are apt to be prolonged, a relatively long-acting agent or one that may be given repeatedly is advisable. A routine employing tribromoethanol (avertin) or paraldehyde in the manner used for the symptomatic treatment of tetanus is suggested, or barbiturates such as pentobarbital or amytal may be used. In experimental animals it is necessary to give anesthetic doses of these agents before complete symptomatic relief is obtained, a procedure which may need to be modified in the treatment of human poisoning.

b. It is not known whether a dangerous degree of hepatic injury can be produced by DDT in humans, either as an after-effect of acute poisoning or incidental to chronic poisoning. However, should there be clinical evidence of hepatic insufficiency, routine procedures for the treatment of lesions resulting from hepatotoxic agents should be employed. These include a diet low in fat and high in protein, carbohydrate, and calcium. Acute hepatic insufficiency may possibly be benefited by the intravenous administration of amino acid mixtures or protein hydrolysates containing added methionine if available.

c. Should DDT be ingested orally, the delay in absorption which occurs should offer ample opportunity for effective local measures. The stomach should be generously washed with water or normal saline, following which 30 grams of magnesium sulfate in 250 cc of water should be introduced through a stomach tube and allowed to remain. Thereafter, all fats should be eliminated from the diet for a period of several days and the patient carefully observed for the onset of the signs and symptoms described above.

6. DDT INSECTICIDE ITEMS. *a.* The DDT insecticide items procured for Army use by the Office of The Quartermaster General are listed below.

Insecticide, pow-der, louse, 2-ounce can. QM Stock No. 51-I-173

Insecticide, pow-der, louse (bulk issue). QM Stock No. 51-I-180

Larvicide, DDT, QM Stock No. 51-L-120
powder, dissolving.

Larvicide, DDT, QM Stock No. 51-L-122
powder, dusting.

Insecticide, spray, QM Stock No. 51-I-305
DDT, residual effect.

Insecticide, liquid, QM Stock No. 51-I-169
finished spray.

Insecticide, spray, QM Stock No. 51-I-310
delousing.

Insecticide, aerosol, 1-pound dispenser, QM Stock No. 51-I-159

Insecticide, DDT, QM Stock No. 51-I-156
emulsion, concentrate.

b. Most of the DDT insecticides are issued as finished products, though a few must be diluted or mixed with other ingredients before use. When certain finished products are not available in the field, they may usually be prepared from Larvicide, DDT, powder, dissolving, which is approximately 100 percent DDT, provided other necessary ingredients are at hand. Directions for preparing the finished products in the field are given under the discussion of the individual items.

7. INSECTICIDE, POWDER, LOUSE, 2-OUNCE CAN. *a.* This item is a mixture of 10 percent DDT in an inert powder, pyrophyllite. It is issued as a finished product for individual use in the prevention and control of infestation with lice. The item is packaged in small, oblong-base, sifter-top cans; approximate size $2\frac{1}{8}$ by $1\frac{1}{2}$ by $2\frac{7}{8}$ inches; 48 cans to a carton.

b. Application. (1) For prevention or treatment of body lice infestations, dust the entire inner surface of underwear and any other clothing worn next to the skin, including the shirt, giving special attention to the seams, the area about the neck, the armpits, waist, shirt tail, and crotch of pants. Dust also along the seams of the outer garments. Rub the treated clothing lightly to spread the powder. About $1\frac{1}{2}$ ounces of the insecticide are required. The application should be repeated after each change of cloth-

ing. If clothing cannot conveniently be removed for making application, unbutton the shirt and trousers and dust the powder liberally by shaking on the inside of underwear or other garment next to the skin. Then pat the clothes with the hands to insure more even distribution of the powder. Eggs (nits) of lice are not affected, but the young lice are killed soon after hatching. Several hours may elapse after dusting before lice are killed. Consequently, the powder should not be relied upon to disinfect typhus patients admitted to hospitals. Delousing spray (QM Stock No. 51-I-310) should be used for this purpose (see par. 13).

(2) For head lice, apply the powder lightly to the hair and rub in with the fingertips. Do not wash the hair for at least 24 hours. Since the eggs are not killed by the DDT, second and third applications should be made at weekly intervals to be fully effective.

(3) For crab lice, apply the powder to all regions of the body having a moderate to heavy growth of hair. Although most frequently occurring in the pubic region, crab lice often are found in other areas of the body. A thorough application is important. Do not bathe for at least 24 hours. Repeat applications after 1 and 2 weeks, respectively.

8. INSECTICIDE, POWDER, LOUSE. *a.* This bulk issue is for use primarily in mass delousing with hand and power dusters. The louse powder is also suitable for control of other insects, such as bedbugs, roaches, ants, and fleas. The powder consists of a 10-percent mixture of DDT in pyrophyllite. It is issued as a finished product, packaged in 5-pound, moistureproof, round, metal containers; approximate size, $6\frac{5}{8}$ by $7\frac{1}{2}$ inches; 6 containers to a box.

b. Group delousing. (1) *Equipment.* (a) The use of mechanical dusting equipment, such as the plunger type hand duster (QM Stock No. 41-D-3755, Duster, powder, insecticide) obviates the need for disrobing. This item is equipped with a 6-inch metal extension tube and delivers an even flow of powder. One duster three-fourths full holds enough powder to treat approximately 10 individuals. Best results are obtained when dusters are not filled completely.

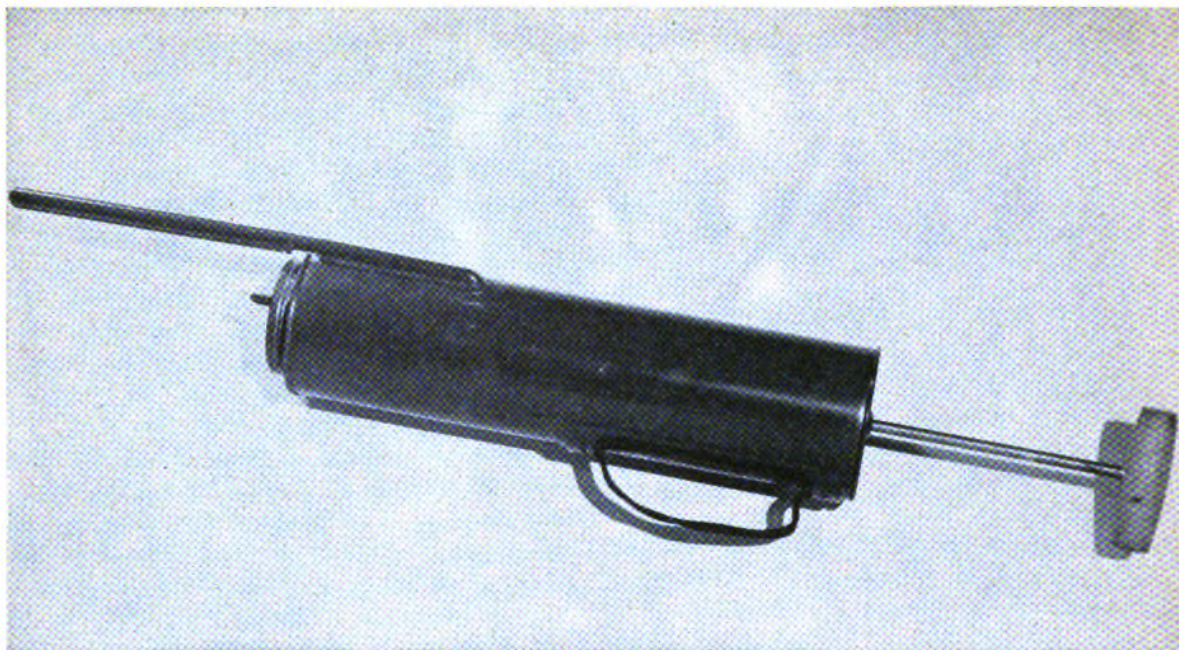


Figure 1. Duster, powder, insecticide, QM Stock No. 41-D-3755.

(b) Power dusting equipment consists of a small portable gasoline engine, an air compressor, 10 lengths of hose with extra lengths for extensions, and 10 dusters (QM Stock No. 60-O-800, Outfit, delousing, gasoline-engine-driven). The dusters are easily detachable and extra units are supplied to enable refilling while

others are in use. One complete unit is capable of delousing 600 or more persons per hour. The use of this power dusting equipment is especially suited for troops in rear areas, prisoners in POW enclosures, civilians adjacent to troop concentrations in occupied territory, and personnel boarding transports.

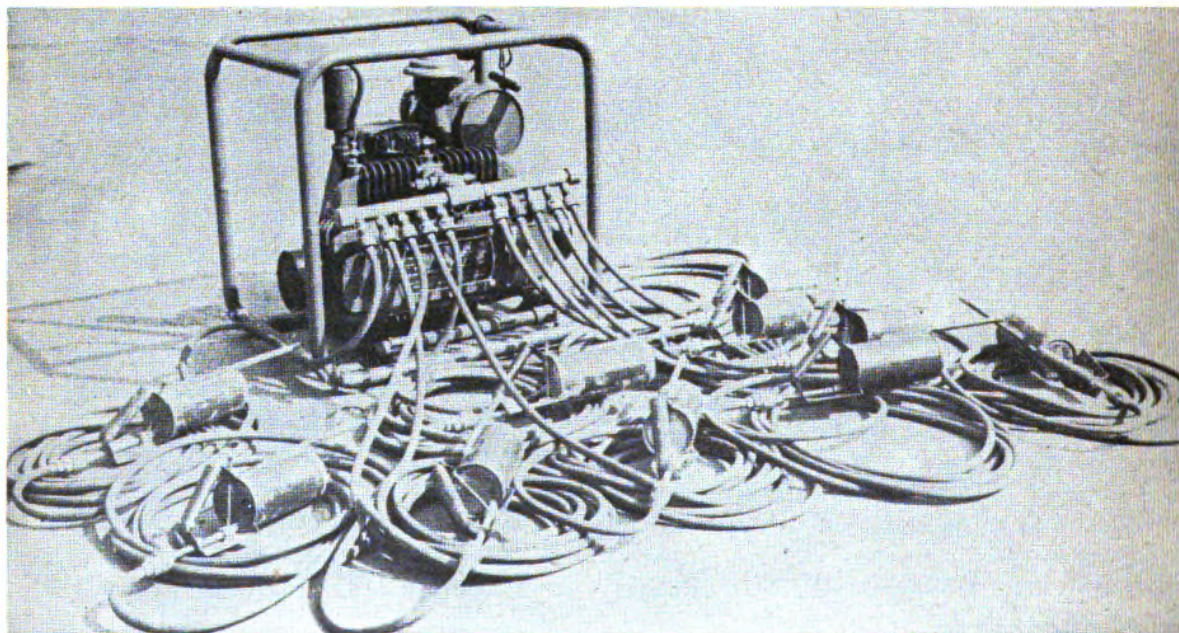


Figure 2. Outfit, delousing, gasoline engine-driven, QM Stock No. 60-O-800.

(2) *Procedure.* (a) The dusting of individuals should follow a definite routine to avoid missing portions of the clothing. A suggested procedure, which may be modified as the situation warrants, is outlined as follows:

1. The men are directed to loosen collar, tie, belt, and then to stand or sit, whichever is most suitable, with hat in hand.
2. First, dust the head, separating the hair to insure even distribution. The hair should be whitened with the dust.
3. The hat is then dusted.
4. Insert nozzle into right sleeve next to the skin, with the subject's arm outstretched *to the side* at shoulder height, and direct powder toward

the arm pit. With the power duster, hold the trigger down until powder is seen to issue from the loosened neck of the shirt. The subject's face should be turned away from the side being dusted. Repeat for the left sleeve.

5. Insert nozzle in the front of the shirt at collar and direct the powder toward the right armpit, toward the stomach and toward the left armpit. The operator stands in front, and subject leans forward with head tipped back.
6. Insert nozzle in the back of the shirt at collar and direct the powder toward the right shoulder, toward the

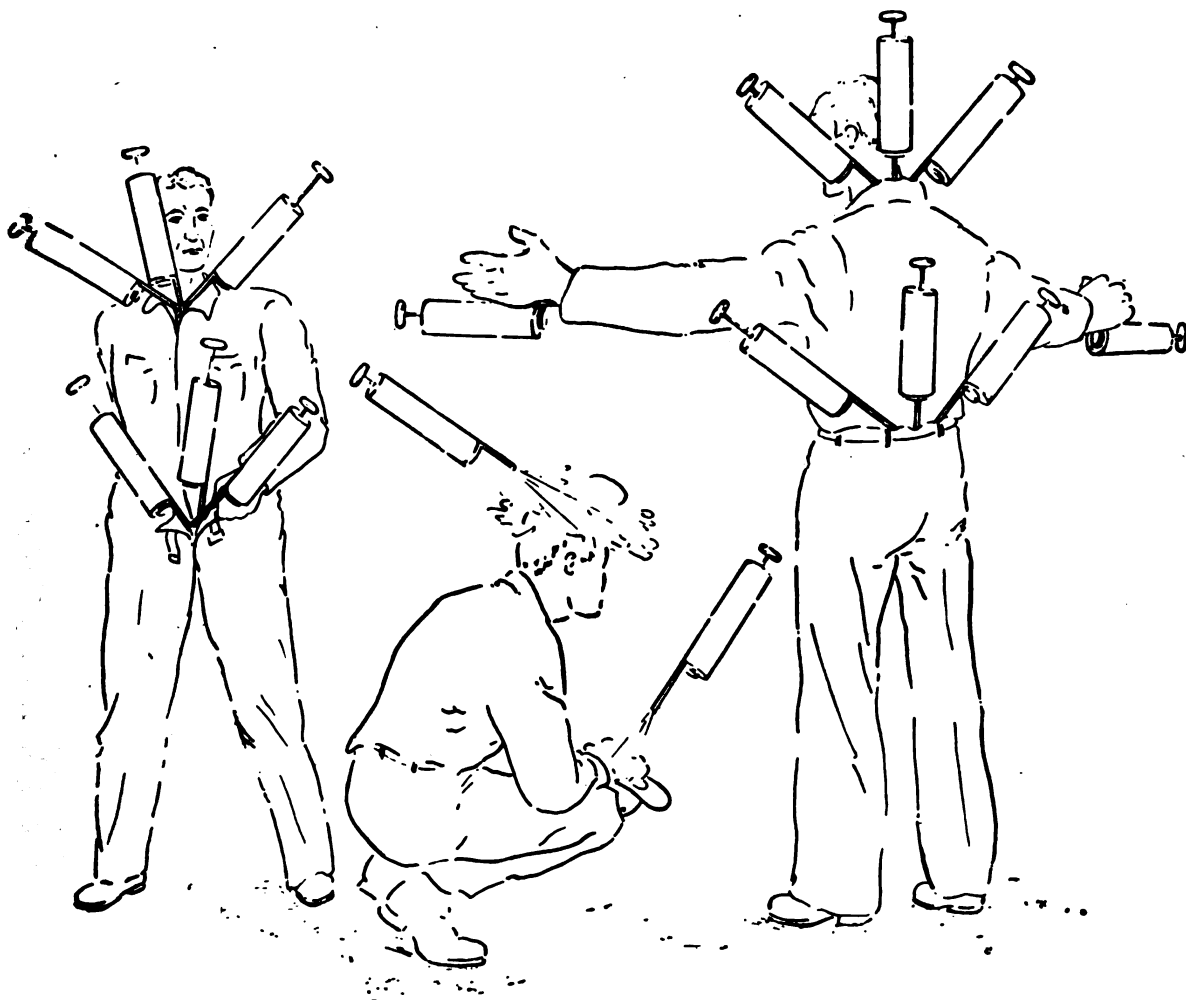


Figure 3. Diagram of procedure for dusting an individual with DDT louse powder.

small of the back, and toward the left shoulder. Operator and subject remain in same relative position as above, but with head of subject bent on chest. Be sure that some powder is dusted on collar itself where lice frequently are found.

7. Insert nozzle in the back of the trousers, next to skin, and direct powder toward the right leg, toward the buttocks crease, and toward the left leg. The operator may remain in the same position and have the subject turn around, or may walk to the back of the subject.

(b) When hand dusters are employed, two full, even strokes are required for treatment of each site. With power dusters, a momentary pressure on the trigger is usually all that is necessary. The exact timing must be learned by experience. In case women are to be disinfested, the same general procedure should be followed where possible; otherwise, liberal use should be made of the powder at the neck and sleeve levels next to the skin and also beneath the lower garments. An adequate amount of powder must be used for each individual; winter dress requires about 1½ ounces of powder.

(c) Since extra clothing and bedding may serve as a source of reinfestation, they should also be dusted with DDT powder.

(d) Infestations with head lice and crab lice may be treated with bulk louse powder. It should be applied as directed for DDT powder in 2-ounce cans (see par. 7b).

c. Ten percent DDT in pyrophyllite is useful for dusting individuals and clothing for the control of fleas. For individual disinfestation, the 2-ounce containers of Insecticide, powder, louse (QM Stock No. 51-I-173), should be used as described in paragraph 7, but for groups, apply the bulk louse powder with hand or powder dusters (see b above). In treating pets, the powder should be rubbed into the fur to minimize the possibility of toxicity to the animals which may result from ingestion of the powder by licking their coat. Application to the back of the animal's neck will clear up the average infestation. The treatment of rooms,

rat burrows, and other flea habitats is discussed in paragraphs 10d and 11f.

d. Insecticide, powder, louse (bulk issue), is also suitable for the control of other insects, such as bedbugs, roaches, ants, and flies (in pit latrines). When Larvicide, DDT, powder, dusting, is not available, bulk DDT louse powder can be substituted for the control of these insects (see par. 10).

9. LARVICIDE, DDT, POWDER, DISSOLVING. a. This item consists of technical grade DDT powder and is issued primarily for the preparation in the field of petroleum oil solutions of DDT for mosquito larviciding (see TB MED 14, Use of DDT As a Mosquito Larvicide). It may also be used to prepare a satisfactory substitute for several other DDT preparations when the finished product is not available; for example, Insecticide, spray, DDT, residual effect (5 percent DDT in kerosene). Larvicide, DDT, powder, dissolving (51-L-120), is packaged in 10-pound, oblong-base, moistureproof, metal containers, four containers to a box.

b. To prepare a 5 percent (weight by volume) solution, powdered DDT is dissolved at the rate of 7 ounces of DDT per gallon of No. 2 fuel oil or similar petroleum product. Pulverize all lumps before adding, if the powder has "caked." The mixture is stirred at intervals until all the DDT is in solution (may require 24 hours). Placing the mixture in the sun may furnish sufficient heat to hasten solution. If the DDT used contains large particles of foreign matter, the solution should be strained or allowed to stand and the clear liquid poured off for use, to prevent clogging of spray equipment.

c. The concentration of DDT in the oil may be varied, depending on method of application. For control of anopheline larvae, it is recommended that oil solutions of DDT be applied at such a rate as to give a dosage of 0.2 pound of DDT per acre, and that application be repeated every 6 to 9 days. A 1.0 percent DDT solution applied at a rate of 0.2 pound of DDT per acre requires approximately 2½ gallons of the solution per acre. To give the same dosage of DDT, two quarts of a 5 percent solution are required per acre. Since the effectiveness depends upon the material reaching the larvae, sufficient oil should be used to permit adequate coverage and

the concentration of DDT adjusted accordingly to prevent waste and overdosage. The minimum amount of oil which can be sprayed and still give good coverage will vary with the type of spraying equipment used. The amount of oil necessary will also depend upon the spreading quality of the oil used and upon the density of vegetation in the area being treated. In breeding places where the larvae are difficult to reach with a larvicide, heavier applications of DDT and oil should be made. In general, with DDT solutions much less oil is required for control than straight oil without the added toxicant. The spray should be applied as a mist to obtain as much drift over the water as possible. A swath width up to 50 feet is suggested, although good control has been obtained for several hundred feet with a finely atomized spray of 5 percent DDT in oil applied at the rate of 2 quarts per acre while a breeze was blowing.

d. When DDT is applied as a larvicide to containers, such as rain barrels, metal cans, and other water receptacles, which are common *Aedes aegypti* breeding places, a prolonged residual larvicidal effect may be obtained. However, residual action of DDT as a larvicide is very limited in many natural water collections which are common anopheline breeding sites, since the mud complex at the bottom apparently binds the precipitated DDT and checks its action. When it is desired to obtain prolonged residual larvicidal action under suitable conditions, 5 percent DDT solutions should be employed at the rate of 2 pounds of DDT per acre (5 gallons of 5 percent DDT oil solution). This is not practicable where the surface film may be lost, due to wind or rain action. Dosages in excess of 2 pounds of DDT per acre are not advised, since no increase in effectiveness is likely to result. With the recommended dosage, effective residual larvicidal action may be obtained for 3 or more weeks, under favorable conditions. Consideration must be given to the fact that dosages of DDT greater than 0.2 pound per acre may kill fish and be harmful to wild life.

e. DDT oil solutions can be applied by any of the methods used in the past for applying oils alone in larviciding (see TB MED 164): pouring solutions from containers such as a bottle, can, or bucket, where numerous, small sepa-

rated areas are to be treated; application by containers of the drip-oiler type for flowing streams; soaking porous materials such as sawdust, sand, or wet gravel, and scattering over the water surface, or placing the porous materials in a bag and submerging in ponds; spraying with various types of equipment available. All are effective means for larviciding with DDT oil solutions within their usual limitations. When drip-oliers are employed, they should be checked frequently, since some of the DDT may precipitate and occlude the opening. Spraying is the method of choice where large areas are to be treated, taking advantage of wind-drift. Sprayer, insect, knapsack type, plunger type, cylindrical shape, 3-gallon capacity (Engineer Stock No. 41-7839.400.030) is designed for use of DDT solutions in larviciding and for residual spraying against adults. The 3-gallon Chemical Warfare Service decontamination apparatus may be used when the above item (knapsack sprayer) is not available, if the nozzle aperture is altered. This can be accomplished by soldering the hole in the spray disk and reboring with a No. 60 wire gauge bit. With this change, effective coverage is possible with a minimum of 5 quarts of DDT-oil solution per acre.

f. *Other uses.* For large-scale area control, specially equipped aircraft may be employed to spray oil solutions of DDT, prepared from Larvicide, DDT, powder, dissolving. Application of 0.2 to 0.6 pound of DDT per acre will give good kill of adult mosquitoes in addition to the larvicide effect. Airplane spraying is most useful in battle zones where the military situation precludes standard methods of mosquito control. It is also advantageous for treatment of large, inaccessible areas (see par. 16). Five percent DDT solutions in oil also may be employed for interior and out-of-door application for residual effect against adult mosquitoes and other insects (see par. 11). Larvicide, DDT, powder, dissolving, tends to agglomerate and is not micronized; consequently it is not suitable for making DDT larvicide dusts (see par. 10).

10. LARVICIDE, DDT, POWDER, DUST-ING. a. This preparation contains 10 percent micronized DDT and 90 percent inert diluent, talc. It is packaged in 5-pound, moisture-proof, metal containers; 8 containers to a box.

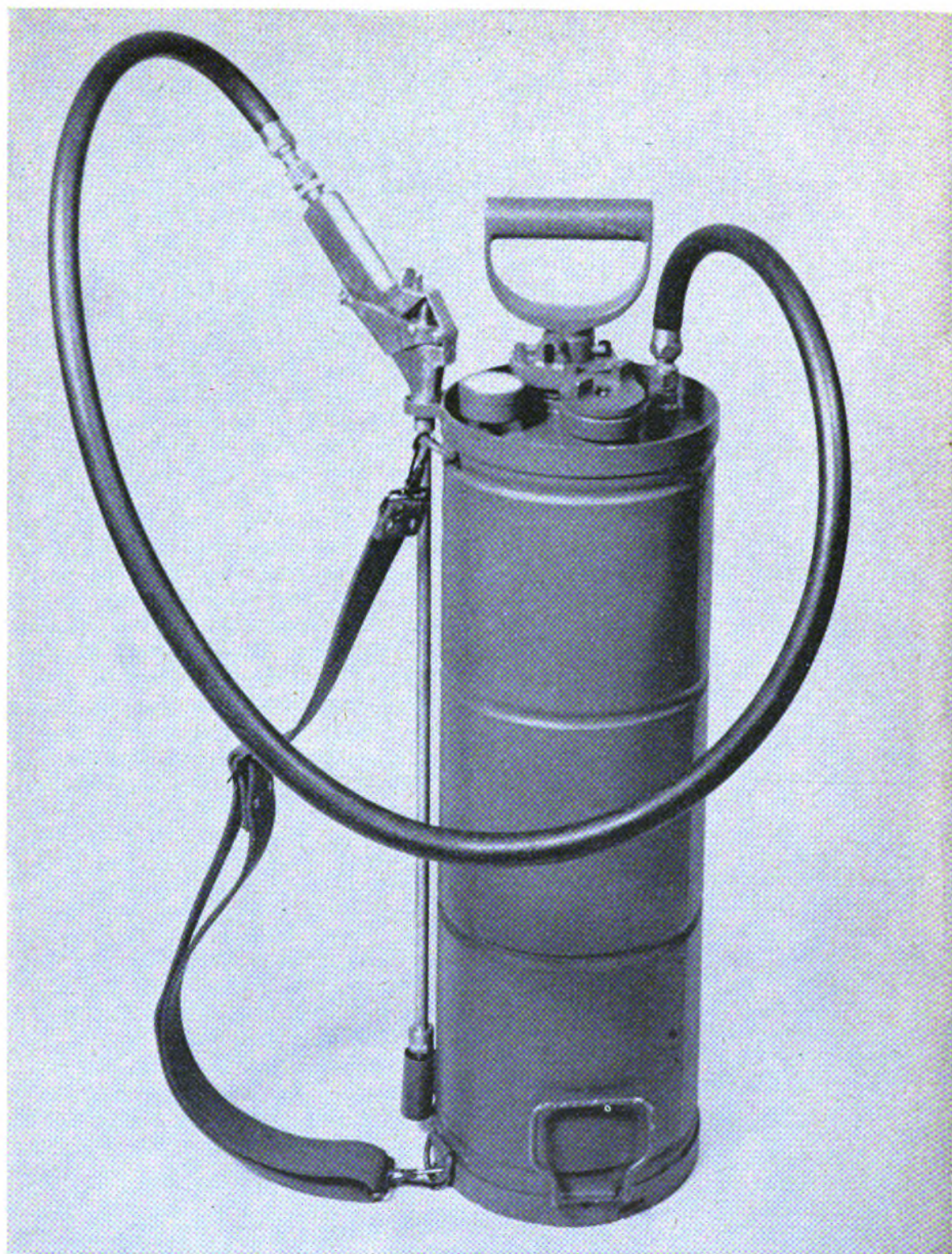


Figure 4. Sprayer, insect, knapsack type, plunger type, cylindrical shape, 3-gallon capacity, designed for DDT larviciding and residual spraying.

The powder is a stock mixture for preparation of dusts primarily for mosquito larviciding. It may also be used without dilution as a lousicide for mass delousing when Insecticide, powder, louse, is not immediately available. It is also suitable, when used full strength, for the control of other insects, such as bedbugs, roaches, ants, fleas, and flies in pit latrines.

b. Mosquito larvae. (1) The DDT in this item has been specially ground (micronized), since a particle size range from 5 to 10 microns is required to obtain the optimum effectiveness against mosquito larvae. The concentrated stock item (10 percent) may be diluted to the desired concentration for larviciding by

adding a suitable vehicle. Any available finely divided material, such as soapstone, road dust, or condemned flour may be used as a diluent. A final dust containing from 1 to 5 percent DDT is suitable for application for temporary control of mosquito larvae; but a 2 percent DDT dust is recommended for average conditions in order to obtain uniform coverage. To prepare a 2 percent dust, dilute the DDT stock mixture for dusting at the rate of 1 part stock mixture to 4 parts inert diluent. In diluting the concentrated mixture, care should be taken to break up all lumps, and the diluent should be added gradually to the concentrate with continual mixing. When all the diluent

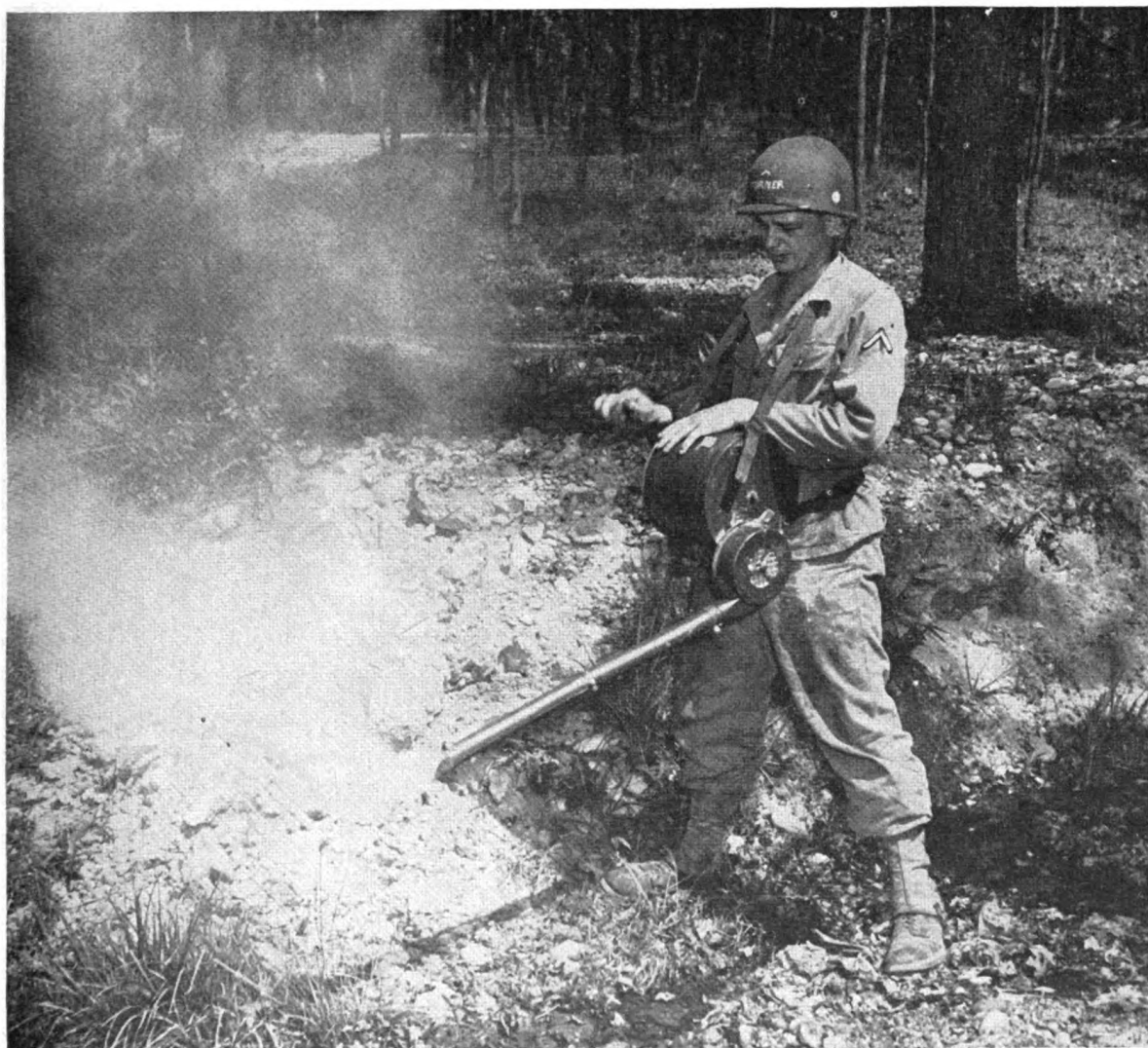


Figure 5. Duster, insect, hand rotary-blower type, for mosquito larviciding.

has been added, the product is mixed thoroughly for an additional 20 to 30 minutes to insure uniform distribution of DDT. For large quantities, a cement mixer, flour mixer, or tumbler may be used if available.

(2) For the temporary control of anopheline larvae the dust should be applied at the rate of 0.2 pound of active ingredient per acre under average conditions. At this dosage, 10 pounds of a 2 percent DDT dust, or 20 pounds of a 1 percent dust, are required per acre. DDT dusts may be applied readily with ordinary ground dusting equipment. The rotary hand duster (Duster, insect, hand, rotary-blower type, 5 to 10 lb capacity, Stock No. 41-3115.5-10) supplied by the Corps of Engineers, is recommended for this purpose. For residual control, a single application of undiluted 10 percent concentrate at the rate of 10 pounds per acre may be used to obtain a larval kill for three or more weeks in waters with thick vegetation, where the dust film will be protected from wind and wave action. As noted in paragraph 9d, residual larvicidal action is not ordinarily obtained with DDT, in contrast to that observed with adult mosquitoes, except under exceedingly favorable conditions. The interval between treatments should be based upon dipping observations. DDT applied as a dust is not as highly efficient against larvae of *Culex* and *Aedes*, which feed below the water surface, as against anopheline larvae. In general, oil solutions of DDT, which are very effective against both anopheline and culicine larvae, are preferable to dusts.

c. Roach control. The dust may be applied lightly in mess halls and kitchens with an ordinary hand-operated dust gun (Duster, powder, insecticide, QM Stock No. 41-D-3755). Not over 10 pounds of powder are necessary to treat the largest mess hall. For best results, the material must be dusted under serving tables, sinks, cupboards, refrigerators, around water pipes and hot water tanks, into cracks and crevices in the walls, under moldings, and other places where roaches hide or run. Cover food, cooking and eating utensils, and table tops during the procedure. The powder is effective until removed by sweeping or cleansing. A disadvantage to the use of a DDT powder in mess halls is one common to all roach powders,

namely, an unsightly appearance. Insecticide, spray, DDT, residual effect (par. 11) being a liquid, is therefore considered preferable for roach control. Also, the insecticide is removed less readily in cleaning and can be used on walls and other places where dust cannot be applied. By use of the residual spray, control of flies and mosquitoes as well as of roaches can be accomplished in a single operation.

d. Flea control. The powder should be applied lightly to the floor and lower parts of walls of infested quarters. In plague and endemic typhus control, the dust should be applied along rat runs, and blown into rat burrows and other flea habitats. This serves to reduce the flea index and will kill fleas which leave the carcasses of dead rats. Repetition of treatment should be based upon duration of effectiveness as determined by local experience. Insecticide, spray, DDT, residual effect, is also effective for the control of fleas. Disinfestation of individuals for fleas is discussed in paragraph 8c.

e. Ants. Dust the powder about doorsills, windowsills, foundations, and other places where ants crawl. An effort should be made to find the nest of the ants. Direct application of the powder to the nest and formation of a barrier of powder at least 3 inches wide around the nest should eliminate ants at their source and simplify control. From the standpoint of economy of time and material, DDT residual spray is preferable for use in control of ants around mess halls.

f. Bedbugs. Although the residual spray treatment (see par. 11h) is preferable and recommended, dust application to the beds, bedding, and cracks in the walls of infested barracks is also effective against these insects.

g. Control of flies in pit latrines. Two ounces of the 10 percent DDT powder per latrine box hole ($\frac{1}{2}$ ounce per square foot) should be applied evenly over the pit contents twice a week. Insecticide, powder, louse (par. 8), is a suitable substitute. This should be supplemented by the application of 5 percent DDT in kerosene (or Insecticide, DDT, residual effect; see par. 11c) to latrine walls, ceiling, doors, and screens as well as to the inside walls and outside of the latrine box and the walls of the pit. The control of flies in pit latrines appears to be primarily from the residual action on the newly

emerged adults which contact the treated surfaces, and to a much less extent on the fly larvae.

11. INSECTICIDE, SPRAY, DDT, RESIDUAL EFFECT. *a.* A characteristic of DDT, in which lies its extraordinary value, is that a deposit of DDT on most surfaces remains toxic to insects for prolonged periods, giving long-term control, which is referred to as *residual effect*. Insects which crawl upon treated surfaces receive a lethal dose by contact with the chemical, and succumb within an hour or more. Residual type spray is designed to take advantage of this characteristic. It should be emphasized that DDT does *not* repel insects. The preparation consists of 5 percent technical grade DDT, 15 percent auxiliary solvent (methylated naphthalene) and 80 percent kerosene. The spray is issued as a finished product in 5-gallon metal containers for use in the control of houseflies, mosquitoes, bedbugs, fleas, *Phlebotomus* flies,

equipped with a variety of nozzles, is suitable for this purpose. A hand sprayer issued by the Quartermaster, Sprayer, liquid, insecticide, continuous spray (Stock No. 41-S-4105), also is satisfactory for the application of residual spray. When these items are not available, the Chemical Warfare Service 3-gallon decontamination sprayer may be used. A disk opening of No. 60 standard wire gauge is recommended for the decontamination type sprayer.

For large-scale operations, a gasoline-engine-driven, air compressor type of paint-spraying unit with spray gun offers an easy and effective means of application, but a mist must be avoided. Since kerosene is of much lower viscosity than that of materials for which the apparatus was designed, the speed of the motor should be adjusted to develop only 10 to 15 pounds pressure per square inch. For mobility,



Figure 6. Sprayer, liquid, insect, continuous spray, Q M Stock No. 41-S-4105, which may be used for applying DDT residual spray, finished spray, delousing spray, and for mosquito larviciding with DDT solutions.

roaches, ants, and other disease vectors and pest insects. An equivalent preparation may be prepared in the field by dissolving approximately 7 ounces of Larvicide, DDT, powder, dissolving (Stock No. 51-L-120), per gallon of kerosene when the standard item is not available.

b. Method of application. (1) DDT may be applied as a residual spray by various methods. The Engineer knapsack type sprayer, which is

the unit may be mounted on a truck, jeep, or other type of conveyance.

(2) When applying to interior surfaces, it is important to use a rather coarse, wet spray (*not a mist*), so that as much of the material as possible will reach and be retained on the treated surface. When the liquid evaporates, the DDT remains on the sprayed object and acts as a residual contact insecticide. Sprayers

should be held close (4 to 8 inches) to surfaces being treated; otherwise part of the spray may blow away or settle to the floor, resulting in an inadequate dosage. Residual spray may also be applied by ordinary paint brushes. This is the most economical means of application for objects such as screens, mesh surfaces, and light cords. The dosage rate for interior application

up to an hour or more may be required before the insects die after contact with DDT treated surfaces, immediate kill must not be expected. Further, the number of dead insects found in treated buildings should not be accepted as the criterion of effectiveness, since many may have hidden or escaped outdoors before succumbing to the lethal action.



Figure 7. Application of DDT residual spray to walls.

should be approximately 200 mg of DDT per square foot, although in some instances lower concentrations have been found to be effective. At this rate, 1 quart of 5 percent spray will cover approximately 250 square feet of surface. The surface should be moistened with the spray but there should be no run-off. Since a period

(3) Since Insecticide, DDT, residual effect contains kerosene, additional precautions should be pointed out:

(a) The fire and explosion hazard of DDT solutions is that of the solvent. When DDT in kerosene solution is applied as a residual spray by competent trained personnel using a hand

pump knapsack type of sprayer, with open flames and temperatures exceeding 100° F. avoided, it may be assumed that no explosion hazard exists. Under these conditions, the fire hazard of liquid kerosene only needs to be guarded against. Electric motors, light bulbs, and other sparking or heating equipment should be kept from the zone of spray. Open fires and smoking should be prohibited until ventilation and drying are complete. Kerosene will fog,

however, when atomized by power sprayers at high pressures and relatively high temperatures. This should be avoided, since it reduces the safety normally associated with kerosene and requires additional precautions.

(b) Prolonged intimate contact of kerosene with the skin will cause a mild dermatitis and should be avoided.

(c) Kerosene eventually causes deterioration of rubber and consequently should not be applied to equipment such as gas masks.



Figure 8. Application of DDT residual spray to screen with paint brush.

(d) When dispensing DDT residual spray indoors for prolonged periods, suitable respirators should be worn by the operators.

(e) The doors and windows of buildings should remain open during the spraying and for several hours following the treatment, until drying and ventilation are complete.

c. Houseflies. (1) The use of residual spray should constitute an essential part of all fly control programs. In mess halls and kitchens where flies are a problem, it is advisable to apply the residual spray thoroughly to the walls, doors, window and door screens, ceilings, cross-beams, light wires, light cords, and similar place where flies rest or where fly specks are seen. All food, cooking equipment, eating utensils, and tabletops must be covered before spraying is begun. An effective adjunct method of using residual spray against flies is the impregnation of 2-inch wide cloth strips by dipping in DDT solution. When dry, they are suspended from ceilings. They should not be used to take the place of residual spraying. An important method in the control of flies is the treatment with DDT of breeding places and immediate surroundings, where the newly emerged adult flies may alight, in conjunction with the application of residual spray to the interior of buildings and to screens, as outlined above. The spraying of refuse piles, garbage cans, loading platforms, storerooms, destroyed ration dumps, stables, compost piles, latrines, and the like is of great value in reducing the fly population. It should be emphasized that the use of DDT in the control of flies should supplement, not replace, the application of the fundamental sanitary procedures, such as proper disposal of wastes. Neighboring civilian habitations are frequently a major source of flies, and may require cooperation of local authorities in applying control measures. Thorough application of DDT residual spray will destroy flies for several weeks to several months or more, the duration of effectiveness depending on the type of surface and degree of exposure of the treated area to weathering. The spray should be applied again when flies reappear in significant numbers.

(2) *Control of flies in pit latrines.* Insecticide, DDT, residual effect, may be used in pit latrines for the control of emerging adults by

applying 2 ounces of residual spray (or 5 percent DDT in kerosene) per latrine box hole (4 square feet of pit contents) twice each week. The spray should be applied evenly over the pit contents. This treatment must be supplemented by application of residual spray to the remainder of the latrine. In treating latrines, the walls, ceiling, door, screens, the inside, and outside of the latrine box and the walls of the pit should receive thorough coverage with residual spray. DDT is less effective on fly larvae than upon the adults, and its efficiency in controlling flies in pit latrines depends chiefly upon its action upon adult flies which emerge and contact treated surfaces.

d. Adult mosquitoes. (1) The use of DDT residual spray offers an efficient and easy method for the continual destruction of adult mosquitoes over prolonged periods of time and provides a highly important means of destroying mosquitoes which transmit malaria, yellow fever, filariasis, dengue, and other diseases. When used in mosquito control, it is necessary to treat thoroughly the walls, doors, ceilings, screens, and other places in buildings, hutments, or tents where mosquitoes tend to rest. Dark corners should receive special attention. Also, mosquito bars may be treated with DDT. In malarious regions, native habitations within mosquito flight range of the cantonment area should receive residual spray treatment to kill infected mosquitoes at the source, and this may well precede spraying of military installations. Certain species of anopheline mosquitoes also rest in outbuildings such as barns, chicken houses, privies, and other sites, and fly into human dwellings at night, to feed, making it necessary to treat such buildings also. Mosquitoes that rest on the walls of living quarters, either before or after feeding, will be killed by contact with the DDT on the treated surfaces. A single application may remain effective against mosquitoes for 2 to 3 or more months. DDT is not an insect repellent and cannot be depended upon to prevent mosquito bites. Recognition of this fact emphasizes the need for continued systematic employment of the "aerosol bomb," protective clothing, screening and maintenance of living quarters, mosquito bars, and other protective measures for the prevention of malaria and other mosquito-borne dis-

eases, in addition to the use of DDT residual spray (see TB MED 110, Use of DDT as an Insecticide to Kill Adult Mosquitoes).

(2) DDT in 5 percent solution in oil or kerosene distributed out-of-doors not only has direct killing effect on adult mosquitoes resting in vegetation and other hiding places, but also may exert residual action on insects that later fly into and rest in treated areas. The degree of residual action will depend largely upon the dosage of DDT applied, rainfall, and other weathering factors. Barrier zones may be established around bivouac areas, isolated observation posts, gun emplacements, and outdoor gathering places such as open air theaters, by spraying vegetation within a radius extending at least 10 yards beyond the boundary of the area to be protected. This is referred to as *barrier treatment*. Effect on the density of mosquitoes should be apparent about 20 to 30 minutes after spraying, but complete results may not be obtained until some hours later. Thus, the procedure should be carried out at least 2 hours prior to use of the outdoor gathering place. Temporary reduction of the mosquito population may be obtained with a dosage of 1 quart of 5 percent solution (0.1 pound of DDT) per acre. Higher dosages are required for prolonged effect. Under favorable circumstances, dosage at the rate of 0.5 pound of DDT per acre has remained effective for several days to a week. Much larger doses, 2 to 4 pounds of DDT per acre (about 5 to 10 gallons of 5 percent solution), have given residual action for 2 to 6 weeks, but, in order to conserve materials, such large amounts should only be used in limited areas. Good results in reducing the adult mosquito population may be obtained by spraying 5 percent DDT solutions in oil with a motor-driven paint sprayer or hand-operated knapsack sprayer. Treatment should be accomplished by spraying a fine mist horizontally into the air at waist height as the operator walks back and forth through the area, making swaths of 20 to 40 feet, depending on density of vegetation and wind velocity. The spraying should be done cross-wind, beginning on the windward side with due allowance for drift. Care should be taken to spray under bridges, culverts, and other likely outdoor resting places. If neces-

sary, a hand-operated, continuous action flit-gun type of sprayer may be used.

e. Sandflies (Phlebotomus). (1) The flight habits of *Phlebotomus* flies render them vulnerable to the residual action of DDT (see TB MED 82, Sandfly (Pappataci, *Phlebotomus*) Fever, and TB MED 183, Visceral Leishmaniasis—Kala Azar). On reaching a building they frequently rest on the outer walls, entering by means of a series of short, hopping flights, with relatively long pauses. Once in a room, they may linger on walls before seeking a blood meal. Application of the residual spray with the equipment, and in the dosage, recommended for houseflies and mosquitoes (*b, c, and d* above) is suitable for the control of sandflies. Sleeping quarters and rooms occupied after dusk should be treated. Spray the inner walls from the floor to ceiling and as much of the ceiling as possible. Apply the spray thoroughly to the corners and upper part of the walls, to the doors, windows, screens, and to the wall immediately surrounding their casements. A greater margin of protection is afforded by spraying the outside of doors, windows and a foot or two of the wall surrounding these openings, in addition to the application of DDT to the interior. Preliminary experiments indicate that the application of DDT residual spray to tents affords considerable protection from, and control of, sandflies. It is suggested that tents be sprayed with 5 percent DDT in ordinary kerosene with application to the interior surface and around the openings, including the flaps, bottom edge, and ventilating apertures. Almost complete reduction in the number of sandflies in habitations and resting places for 2 months or longer is obtained following treatment with residual spray.

(2) Species of sandflies vary in their flight and resting habits. In some places local area control may be at least partially obtained by extending the spraying program to include the out-of-door application of DDT, thus denying to sandflies their customary outdoor shelters or breeding places, and interposing lethal barriers between sandflies and the houses to be protected. The application of DDT sprays to stone masonry, stone walls, vegetation, buttresses of trees, and other resting places within flight range of

human habitations, in dosages recommended for residual killing of adult mosquitoes, is suggested (see *d* (2) above).

f. Fleas. Spraying for control of fleas in buildings is conducted in a manner similar to that for flies, except that special attention should be given to the floors and lower parts of walls. On earthen floors the dosage must be increased. Beds and furniture should also be sprayed. A single application is highly effective in eradicating fleas. Retreatment should be based on local observations of the duration of effectiveness. Excellent results can be obtained outdoors by spraying infested yards and rat harborages. For control of fleas on the body, on clothing, and on pets, see paragraph 8c. *Do not use* the liquid spray.

g. Roaches. Roaches are usually a major problem in mess halls and kitchens. The residual spray when used to control roaches is applied by ordinary hand sprayers, or by power sprayers, to their resting and hiding places under moldings, serving tables, sinks, cupboards, refrigerators, in food carts, around water pipes and hot water tanks, in cracks and crevices of the walls, floor, and furniture, and similar places. Particular attention should be paid to all harborages and the area immediately surrounding them. In general, roaches prefer places to hide where there is a certain degree of warmth, but they will also hide behind any object which will shield them from light. Areas treated should be well coated with the spray to insure maximum contact between the roaches and the spray residue. Before commencing the spraying procedure, care should be taken to prevent contamination of food and mess equipment. The necessary fire precautions must be observed. Spraying for flies and cockroaches in one combined operation is the most practicable and economical method of using the residual spray. Although 10 percent DDT in powder form can also be used in roach control, the use of residual spray is considered preferable for reasons stated previously (par. 10 c). Thorough application of residual spray, while not rapid in initial results, is highly effective and will give control of roaches for 1 month or longer. The duration of the effect will depend to some degree on how quickly the residue is removed by the daily cleaning of the mess hall. Careful check should

be kept of the roach population of the buildings treated. When counts indicate that roaches are beginning to increase, retreatment of the premises should be made. Frequent inspections and application of "spot treatments" wherever a harborage is known to exist will lengthen the interval before a thorough retreatment is necessary. The floor areas that are scrubbed daily will require more frequent spraying than walls and shelves, which are washed less often. DDT residual spray treatment may not be equally effective against all species of roaches.

h. Bedbugs. (1) For control of bedbugs, from 4 to 6 ounces of the 5 percent DDT residual spray are required per bed, including springs and mattresses. In treating beds particular attention should be given to the underside, corners, joints, crevices, springs, and other favorite hiding places. Canvas cots should be sprayed similarly. In spraying mattresses, special care should be placed on treating all seams, crevices, and tufts. If no spraying equipment is available, the solution may be applied by means of a paint brush; a slight moistening of the surface is sufficient. In addition to the bed, springs, and mattresses, the spray should be applied to the walls and posts of rooms to a height of approximately six feet. Any cracks in the wall where traces of bedbugs are noted should receive additional application of the spray. It may be necessary, when infestation is particularly heavy, to treat blankets, wall lockers, and barracks bags also, but in most instances the treatment of beds, mattresses, and walls will suffice to control bedbugs. Open windows and doors of the barracks to ventilate thoroughly before reoccupation. It is desirable to conduct spraying in barracks during the morning in order that they may be reoccupied the same evening. Approximately 4 hours are required to air out a barracks. Appropriate fire precautions should be observed (see *b* above). The residual spray acts slowly, but the bedbugs should be dead within 24 hours after application. It is advisable that this be explained to the occupants of the barracks in case they find live bedbugs after reoccupying barracks the same day. A thorough treatment will eradicate all bedbugs and usually prevent reinfestation for over 6 months. The use of DDT residual spray in bedbug control, because

of its simplicity and prevention of reinfestation, should supplant fumigation methods.

(2) In barracks, spraying may be facilitated by stacking mattresses eight high in the middle of the floor, and then standing the beds on end

against the wall with the underside facing the sprayer. During application of the spray to the beds, the surplus spray will reach the wall behind the beds. Crevices and cracks in the wall and special harborages require additional



Figure 9. Applying DDT residual spray to beds placed on end against the wall.

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treatment. For expeditious handling of mattresses, a team of two men can conduct the treatment, one to do the spraying, the other to remove each mattress after spraying.

(3) An alternate procedure follows for treating barracks to control bedbugs, which does

not require movement of beds, and which has proved practicable and is used widely. Clothes and other equipment are laid upon foot lockers and covered with blankets in the center of the barracks. The mattresses are folded over on the bed springs, as shown in figure 10. The beds, springs, mattresses, and walls are sprayed with the DDT solution as recommended in (1) above. This procedure is suitable for any type of barracks, particularly where "double-

decked" beds are used, and eliminates the need for moving the beds and stacking mattresses upon the floor.

i. Ants. Apply, as described in paragraph 10e, to nests, door sills, window sills, foundations, and other places which ants frequent. An



Figure 10. Application of DDT residual spray to beds and mattresses with knapsack sprayer.

not require movement of beds, and which has proved practicable and is used widely. Clothes and other equipment are laid upon foot lockers and covered with blankets in the center of the barracks. The mattresses are folded over on the bed springs, as shown in figure 10. The beds, springs, mattresses, and walls are sprayed with the DDT solution as recommended in (1) above. This procedure is suitable for any type of barracks, particularly where "double-

ordinary flit-gun type of sprayer is suitable for its application in the average case of infestation. Residual spray is considered the insecticide of choice for control of ants around mess halls. For other locations, either this spray or 10 percent DDT in powder form may be employed. Lawns or grass plots where ants are prevalent had best be treated with DDT powder, due to the fact that the kerosene in DDT residual spray may cause the grass to die.

12. INSECTICIDE, LIQUID, FINISHED SPRAY. *a.* This item is a general utility spray consisting of 1 percent DDT and 2½ percent thanite dissolved in kerosene. It is a finished product, packaged in 5-gallon metal containers.

b. The spray is applied directly on the insects by means of an ordinary flit-gun type of sprayer (QM Item Stock No. 41-S-4105) to obtain rapid kill. No special precautions need be taken other than those which will exclude gross contamination of food. The effectiveness of thanite spray against insects, particularly flies and mosquitoes, has been enhanced by the inclusion of DDT in the preparation. This spray should not be used with the primary intent of obtaining residual effect, since the DDT content is low.

13. INSECTICIDE, SPRAY, DELOUSING.

a. This insecticide is a stock solution consisting of 6 percent DDT, 68 percent benzyl benzoate, 12 percent benzocaine (ethyl p-aminobenzoate) and 14 percent wetting agent. The item is packaged in 1-gallon and 5-gallon containers. For application, the stock solution must be diluted with 5 parts of water by volume to form a 1 percent DDT aqueous emulsion. It should be noted that the previous formula under which this item was procured contained pyrethrum and was issued as a finished spray ready for use. The new DDT item should be mixed just prior to applying, only sufficient quantity prepared for the estimated needs, and used within 24 hours.

b. Delousing spray was developed primarily for use on individuals against louse infestation where immediate and complete disinfection is desired. It is employed in conjunction with methyl bromide or steam sterilization methods of delousing clothing and equipment, where individuals are first required to take a bath. The spray is both lousicidal and ovicidal. This item is not intended to supplant regular DDT louse powder treatments (pars. 7 and 8) or the louseproofing of undergarments (par. 15).

c. The method of application depends to a large extent upon the number of persons to be deloused. The insecticide may be applied by hand, shaker type bottle, or sprayer. The materials are most conveniently applied in the form of a spray when any considerable number

of individuals are to be treated. The ordinary hand sprayer (Stock No. 41-S-4105) issued by the Quartermaster can be used for smaller groups, while a power sprayer may prove more suitable for large-scale treatments. All hairy portions of the body, including the head, should be thoroughly sprayed, using a fairly coarse spray to avoid misting, and holding the sprayer about 4 inches from the part being treated. Approximately ⅔ ounce is required per individual. Protect eyes during application. The material need not be allowed to dry before putting on the clothes. Treated individuals should not take a bath for 24 hours and if possible should wear the same underclothing for at least 2 to 3 days after treatment, since the ingredients are absorbed by the garments from the skin and serve to protect against reinfestation. For treatment of head lice infestations, when the hair is not cut short, about ⅓ to ½ ounce is required per individual. A thorough application kills all lice and nits on the body and thus insures complete disinfection.

14. INSECTICIDE, AEROSOL, 1-POUND DISPENSER.

a. This handy, self-discharging aerosol insecticide dispenser, commonly referred to as the "aerosol bomb," has established itself securely in the insect control armamentarium. It has proved invaluable to troops for adult mosquito control in highly malarious areas. The item is issued as a small 1-pound steel cylinder under pressure, equipped with a release valve, and is packaged 24 to a carton. The aerosol insecticide formula has been altered recently to include DDT, in order to increase its effectiveness. The new formula consists of 3 percent DDT, 2 percent pyrethrum extract (20 percent), 5 percent cyclohexanone, 5 percent hydrocarbon oil, and 85 percent Freon-12. The cyclohexanone is an auxiliary solvent to permit the solution of the DDT content. The freon is nontoxic to man, noninflammable, and is used simply as an expellent to dispense the other ingredients. Dispensers containing the new formula may be identified by the label and the olive drab color in contrast to the black color of those remaining in stock which contain pyrethrum but no DDT.

b. The dispenser is useful for spraying all types of enclosures, such as barracks, billets, tents, bomb shelters, trenches, fox holes, jungle



Figure 11. Insecticide, aerosol, 1-pound dispenser ("aerosol bomb"), QM Stock No. 51-I-159, showing two types issued at present; both contain the same insecticide formula.

shelters, mosquito bars, jungle hammocks, and gun emplacements, as well as aircraft and ships. Forward areas should be supplied with the dispensers in preference to rear bases where other mosquito control measures can be employed. The insecticide is released in an almost gaseous form (aerosol) which pervades the atmosphere. In contrast to ordinary sprays, it remains suspended in still air 2 or more hours, thus giving continued protection against insects entering the enclosure for a while after the application, in addition to killing those present at the time of spraying.

c. A closed pyramidal tent requires only 10 seconds spraying and 3 seconds are sufficient for a pup-tent. Four seconds spraying is adequate for each 1,000 cubic feet (10 x 10 x 10). The aerosol should be dispensed only for the time indicated. Wastage due to overdosage is a

common error. To spray a room or hutment, the container is carried rapidly about the enclosure while the aerosol is allowed to discharge. No direct hits on the insects should be attempted, as this wastes insecticide. The new aerosol is effective against adult mosquitoes, sandflies (*Phlebotomus*), and many other biting flies. The DDT-pyrethrum aerosol is also lethal to houseflies, cockroaches, bedbugs, ants, spiders, and other insects, but its recommended use is primarily to kill mosquitoes and biting flies. Although regular use of the DDT-pyrethrum aerosol may gradually build up a toxic residue on the walls and objects on which it is deposited, the residual type spray (QM Stock No. 51-I-305) should be applied when control by a residual effect is desired. Aerosols have been used successfully to give protection against mosquitoes under outdoor conditions, but more eco-

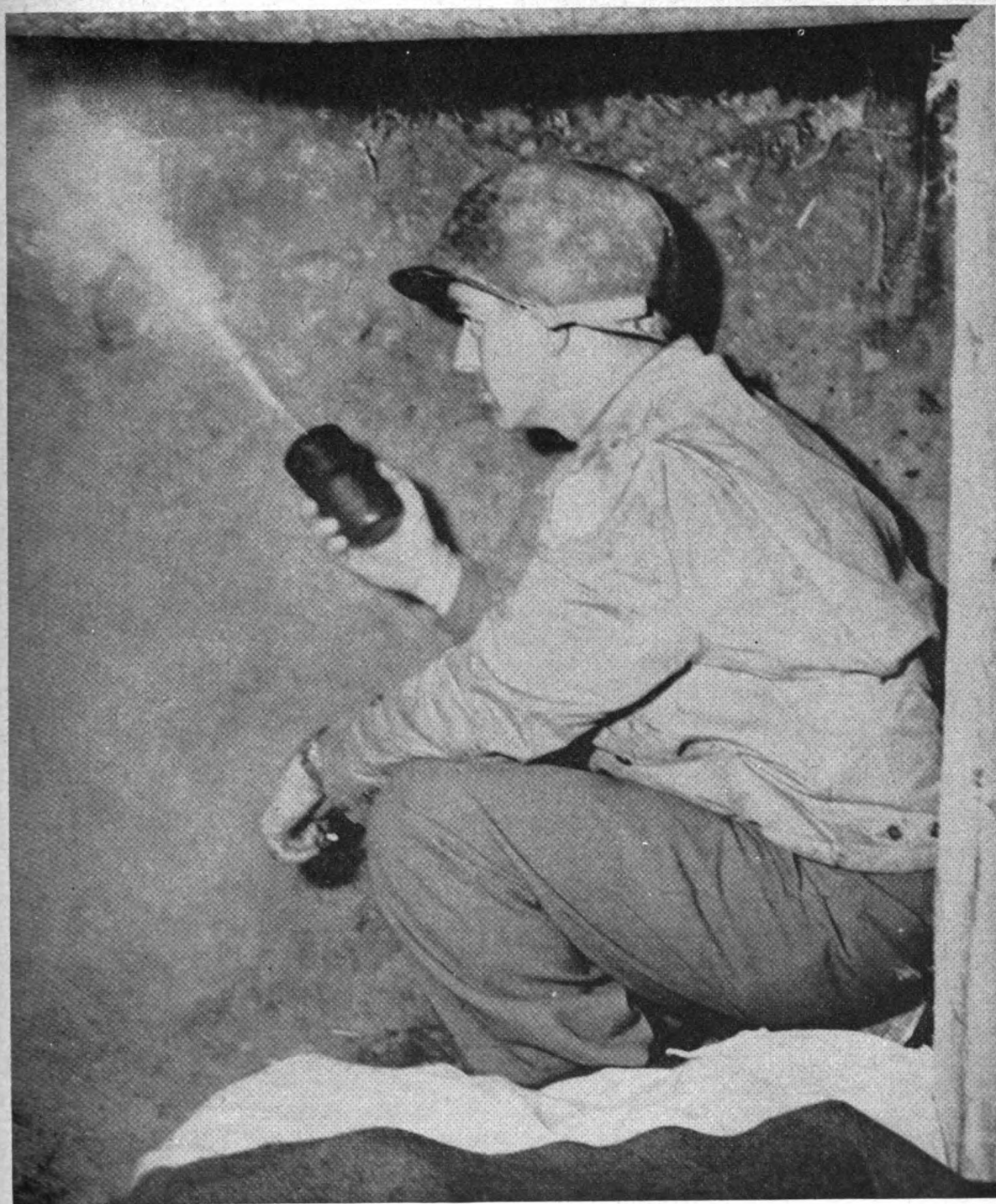


Figure 12. Use of insecticide, aerosol, 1-pound dispenser.

nomical methods of outdoor control and the need for the dispensers for protection in habitations militates against their use out-of-doors, except for front line troops.

d. Disinsection of aircraft. The insecticide aerosol dispenser is convenient and extremely suitable for disinsecting the interior of aircraft. It thus aids materially in preventing the transport from one area to another and the implantation of insects which are vectors of disease or which constitute economic hazards. Spraying should be conducted according to the provisions of AAF Regulation No. 61-3 (or supersessions thereof) which lists the localities between which disinsection must be practiced.

15. INSECTICIDE, DDT, EMULSION CONCENTRATE. *a.* This item contains 25 percent by weight of DDT, 10 percent emulsifier, and 65 percent xylene, packaged in 5-gallon metal containers. It is a concentrate for use primarily in preparing a 2 percent aqueous emulsion for louseproofing clothing. It is also suitable for use in making emulsions for mosquito larviciding, for residual spraying against mosquitoes, flies, bedbugs, and other insects, and for the impregnation of mosquito bars. If the stock concentrate is not obtainable and the ingredients are available, the emulsion concentrate may be prepared by first dissolving the DDT in the xylene and then adding the emulsifier (Triton X-100). The percentage of each ingredient is by weight.

b. Louseproofing. It should be noted that Army experience has shown that dusting of clothing with either bulk louse powder or individual 2-ounce cans of the powder (see pars. 7 and 8) is a more simple and practicable means of preventing and eradicating louse infestations in the field than the impregnation of underwear, and has generally been preferred to the latter method.

(1) For the impregnation of clothing with the emulsion, the recommended amount of DDT is 2 percent of the dry weight of the garment. This dosage may be obtained by dipping the clothing in a 2 percent DDT aqueous emulsion, prepared by adding 1 part by volume of emulsion concentrate to 11 parts of water, and wringing moderately dry. When one individual is treating a large number of garments, tongs or

other means of dipping the clothing should be used rather than the bare hands. A two-piece suit of underwear (50 percent wool) absorbs about 1 quart of the emulsion. Any suitable container or equipment may be used for dipping the garments.

(2) A 30-gallon container will hold enough emulsion to impregnate 125 suits of underwear. A regular laundry wringer facilitates the treatment of a number of garments. Using three men for the operation, one for dipping, one to operate the wringer, and one to hang up the garments, about 1½ hours are required to treat the above number of suits. The emulsion does not affect the rubber rollers of the wringer during the time required for the treatment.

(3) Individuals can prepare a small lot of the emulsion in their helmets or in a pail and dip their own underwear. About 1 quart of the emulsion should be poured on a suit of woolen underwear in the container. It will absorb this amount of liquid and be thoroughly wet. The garment should then be removed from the container and pressed well, to distribute the emulsion throughout the cloth.

(4) Mobile or larger laundry units and CWS clothing impregnation units have been used to impregnate garments with the emulsion on a large scale. The garments are dipped in the emulsion contained in the wash wheel, then drained, centrifuged, and dried.

(5) Suits of woolen underwear impregnated with the recommended dosage of DDT are effective in killing lice through 6 or 8 washings with soap and water. Cotton summer underwear (shorts and sleeveless shirts) impregnated with DDT have also given good control of lice. However, because of the smaller area of skin coverage, this type of underwear is slower in reducing the infestation than the winter type underwear. Impregnation of woolen underwear with the aqueous emulsion will cause some shrinkage and may necessitate resizing.

c. Other uses for emulsion concentrate. (1) The emulsion concentrate may be used to prepare aqueous emulsions for use as a residual spray against mosquitoes, flies, and bedbugs, and as a mosquito larvicide. To obtain a 5 percent emulsion, the stock concentrate is diluted with 4 parts by volume of water. Any clean

water (hard, soft, or sea water) may be employed in preparing the emulsion. If the emulsion is used in spray apparatus, special care of equipment should be taken after use to prevent corrosion or rusting. If upon standing, a creamy layer forms on the surface of the emulsion, indicative of breaking, the emulsion is still suitable for use and needs only to be stirred thoroughly before it is poured into the sprayers.

(2) In using the emulsion as a residual spray, the concentrations of DDT and the methods of application are the same as for the 5 percent DDT-kerosene solution (see par. 11). The emulsion preparation should not be used in tightly closed structures, such as covered pit latrines, because of the hazard of explosion of xylene fumes.

(3) Similarly, for use as a mosquito larvicide, the methods and dosages employed in dispersing DDT-oil solution from the ground apply to the emulsion (see par. 9). The concentrate has the distinct advantage that for larviciding it merely has to be diluted to the desired concentration of DDT with water from larval breeding places or from any other convenient source. Since a small quantity of the concentrate will control mosquito larvae over relatively large areas, the supply problem in the field is simplified.

(4) In general, DDT emulsions are considered equally effective as DDT-oil solutions for residual spraying and mosquito larviciding. The emulsion is not blown off the water surface by wind to the same extent as oil, is more effective against culicine larvae, but probably constitutes a greater hazard to fish than do oil solutions. DDT oil solutions have had more widespread use than emulsions, due to the general availability in the field of oil solvents for DDT powder, whereas the supply of the ingredients, auxiliary solvent, and emulsifier of emulsion concentrates is limited.

16. SPRAYING OF DDT FROM AIRCRAFT. *a.* The immense potentialities of DDT disseminated by aircraft for the control of mosquitoes and flies, particularly in forward areas, were recognized almost immediately after the insecticidal properties of this agent reached the attention of the armed forces. Since that time, large-scale tests have been performed by various organizations in the United

States, and numerous independent investigations have been conducted in theaters of operations. The following general conclusions have been reached:

(1) The dissemination of DDT by aircraft is a practicable method for the control of mosquitoes and, to a lesser extent, of adult flies.

(2) Adult mosquitoes as well as larvae are destroyed by aerial spraying.

(3) Prolonged residual effect is not obtained through aerial spraying with present methods.

(4) The dispersal of DDT by aircraft for mosquito and fly control should be considered as a weapon of military necessity to be used when it offers sufficient economy of manpower to justify its use, when there is insufficient time to establish effective ground control, or when circumstances prevent access to mosquito breeding sites. It must never be employed at the expense of residual treatment of native habitations and Army billets in fixed and semifixed installations or at the expense of other insect control measures.

(5) In populated regions consideration must be given to possible harmful effects of large-scale application of DDT on beneficial insects, agriculture, fish, and other wild life. In combat areas the urgency of the military situation may require that such considerations be ignored. To prevent indiscriminate application of DDT in the United States, projects for the dispersal of DDT by aircraft must be approved by the Army Committee for Insect and Rodent Control in accordance with WD Circular 207, 1945.

b. Equipment for spraying DDT from aircraft. In the development of aerial spraying methods, primary consideration has been given to the development of simple and practicable equipment. Emphasis has been placed on the modification of existing Army equipment whenever possible. When new equipment has been devised, every effort has been made to insure that it could be easily and quickly installed or removed from aircraft, that it did not significantly alter the flight characteristics of aircraft, and that the maximum utilization was made of "prop wash," down drafts, and other factors of aerodynamics. Several types of apparatus have been devised and are described briefly in TB MED 134 and TB MED 182.

The spraying devices which so far have proved most useful in the field are described briefly below.

(1) *Husman-Longcoy sprayer.* (a) This portable spray unit was designed for installation in the L-4 plane (Piper cub), but may also

be installed in the L-5 plane. The unit consists of an insecticide reservoir which is installed in the rear compartment of the plane. In the L-4 plane the reservoir holds 25 gallons of solution. The spray equipment in liaison type aircraft has been found to be well suited for treatment of small bases or sites where the type of terrain requires a slow-flying plane with maximum maneuverability.

(b) A recent modification of the Husman-Longcoy spray equipment has resulted in a spray unit which gives wider swaths. Instead of using a venturi and outlets underneath the

increased from 40 to 60 feet, which was obtained with the original venturi type of equipment, to 80 to 90 feet.

(2) *Vertical discharge pipe.* In an effort to develop a method of spraying DDT from aircraft having large pay-loads, equipment has been devised for B-25 and C-47 planes. A type of spray apparatus with a vertical discharge pipe appears to be the most simple and practicable development. The pay-load of insecticide for the B-25 is 550 gallons and for the C-47, 800 gallons. The tanks are carried in the bomb bay or cabin. The DDT solution is allowed to

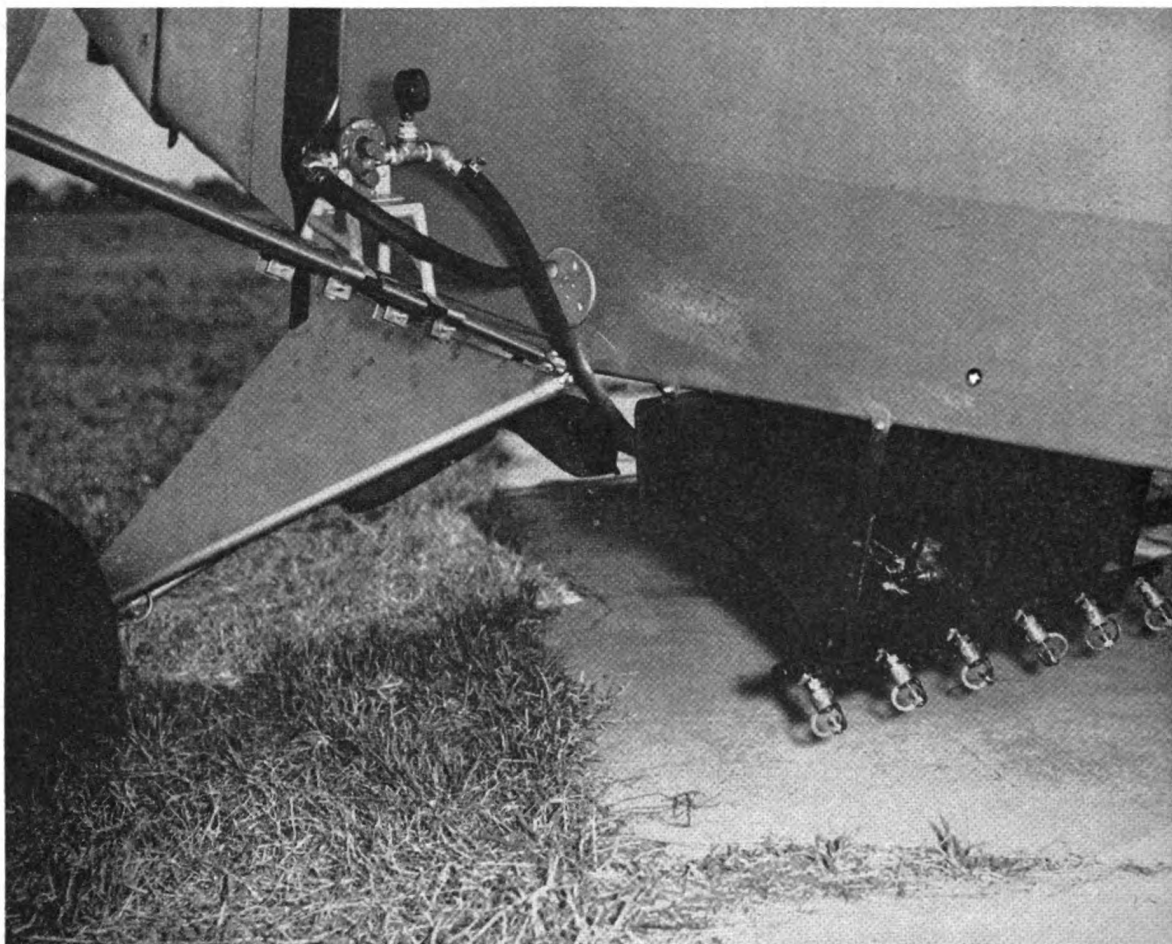


Figure 13. Husman-Longcoy sprayer for L-4 plane.

flow by gravity from the tanks into the spray dispenser and a cut-off valve is used to regulate the flow. A simple vertical $4\frac{1}{2}$ -inch pipe serves as a discharge outlet. This pipe projects about 18 inches below the fuselage and is cut off at a 45° angle with the opening to the rear or downwind side. With the valve completely open, the liquid is emitted at a rate of $3\frac{1}{2}$ gallons per second into the slipstream. Field trials using 5 percent DDT in No. 2 fuel oil at the rate of 0.3 to 0.6 pound DDT per acre, have given good

(2) *Wind.* Favorable winds, with proper velocity and direction, may be used to advantage to disseminate fine sprays, dusts, and aerosols containing DDT. Use of wind is particularly helpful in treating inaccessible water surfaces, and areas with dense jungle growth, for control of adult and larval mosquitoes. Excessive winds may disperse the sprays or dust beyond the areas to be treated.

(3) *Temperature.* Convection currents may carry small droplets of sprays upward and pre-



Figure 14. L-4 (Cub) airplane equipped with breaker bar spray booms, with rotary pump powered by a four-bladed wind-driven propeller.

control of adult and larval mosquitoes in jungle terrain.

17. SPECIAL CONSIDERATIONS IN USE OF DDT. *a. Meteorologic conditions.* (1) *Rain.* DDT will adhere to surfaces of vegetation, but repeated or heavy rains remove considerable amounts of the insecticide. The overflow of permanent or semipermanent bodies of water due to heavy precipitation reduces the DDT content, interrupting its larvicidal action and necessitating retreatment.

vent uniform deposition of DDT. Interference from convection, particularly in spraying from aircraft, may be reduced by application of the insecticide in the early part of the morning when most suitable meteorological conditions prevail.

(4) *Vegetation.* Protection is afforded aquatic stages of mosquitoes by dense vegetation in the breeding sites. It also interferes with the uniform distribution and spreading of larvicides over the water surface. In airplane dis-



Figure 15. L-5 airplane dispersing DDT spray by the use of breaker bar spray booms mounted beneath each wing.

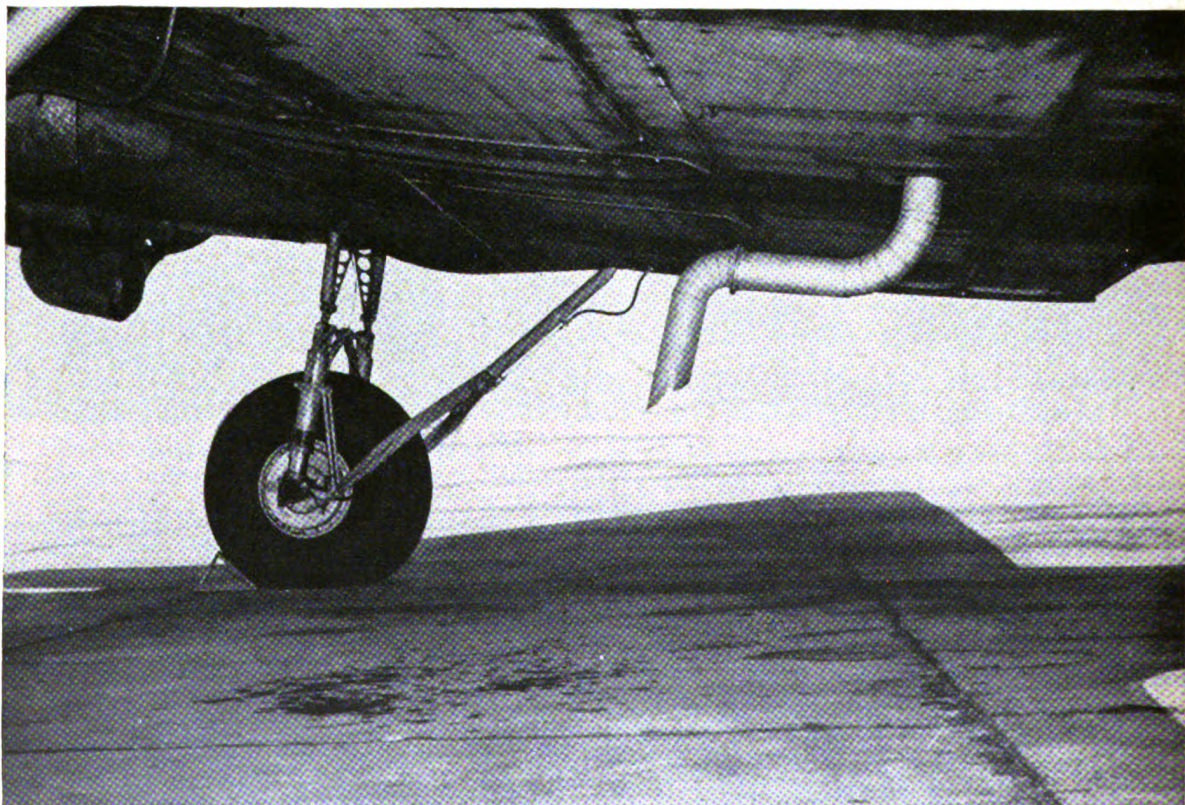


Figure 16. Vertical discharge pipe dispenser in place on C-47 airplane.

semination of DDT sprays, dense jungle growth requires the application of heavier dosages of insecticide spray of a proper particle size range to penetrate the protective canopy than is necessary for relatively open areas. However, vegetation in larval breeding pools may prevent the disruption or removal of the toxic surface film by wind or wave action.

b. Fish and beneficial insects. When possible damage to fish and other wildlife is an impor-

criminate use of DDT might play in upsetting the biological balance in nature. Therefore, in agricultural regions the proposed treatment of extensive areas with DDT, particularly by airplane distribution, should be approached with caution.

c. Effect of DDT on plants. There is little or no evidence to indicate that DDT itself causes significant injury to plants under natural conditions. However, when oil solutions or emul-

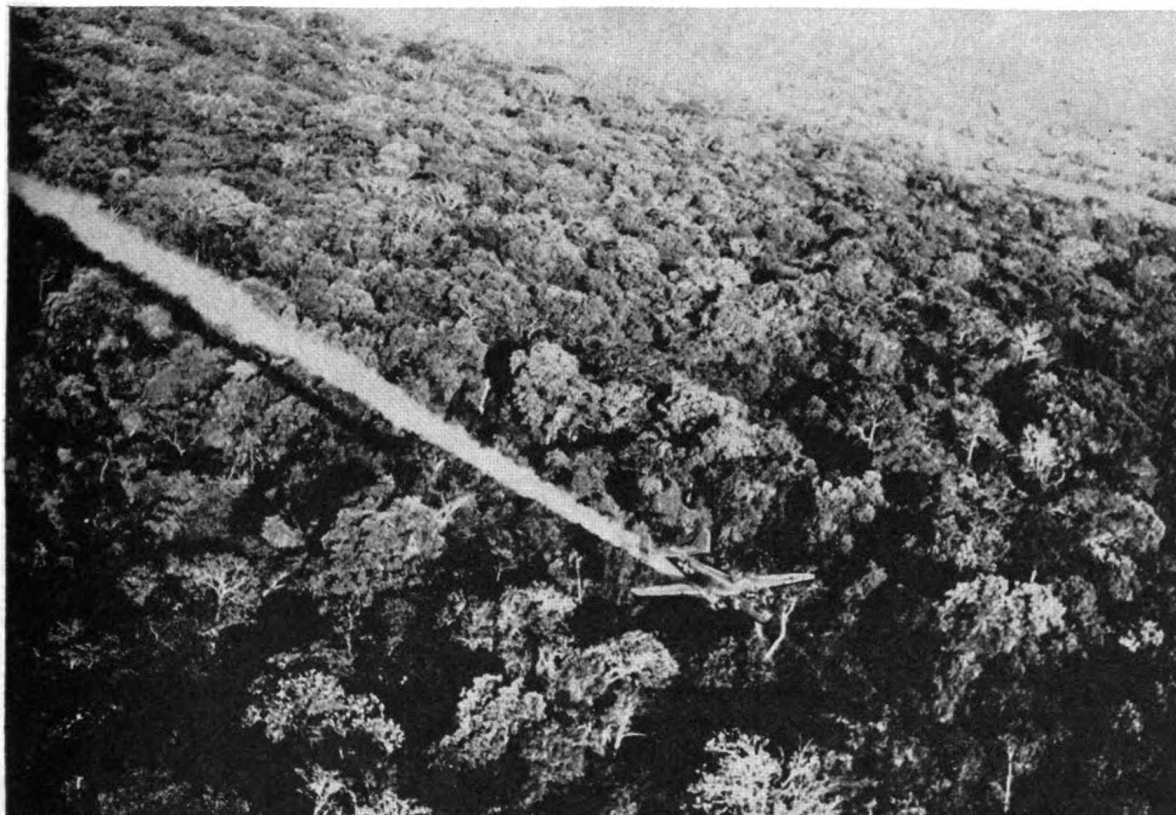


Figure 17. B-25 airplane with vertical discharge pipe showing spray plume.

tant consideration, careful application must be made to avoid doses greater than 0.2 pound per acre of water surface. The killing of fish during larvicidal operations may destroy beneficial species which feed on mosquito larvae. DDT kills beneficial insects as well as those which are harmful. The effect of DDT on insect predators of mosquito larvae varies greatly with different species, but heavy dosage of DDT is lethal to most aquatic insects. As yet, little is known of the role which widespread and indis-

sions of DDT are applied directly upon vegetation, spotting, yellowing, and distortion of the foliage may result. This is due to the solvents rather than to the insecticide. Emulsions or oil solutions of DDT applied to open water, but not directly upon plants, cause no apparent damage to growing rice and no decrease in yield. Larvicide, DDT, powder, dusting (par. 10), may be conveniently used where there is any hazard to crops from application of DDT oil solutions or emulsions.

Appendix

DDT IN INSECT CONTROL

Insect to be controlled	Place of treatment	DDT insecticide	Amount and method used
A. FLY AND MOSQUITO ADULTS.	1. Enclosed spaces: barracks, rooms, barns, airplanes, pup tents, fox-holes.	<p>a. INSECTICIDE, AEROSOL, 1-Lb DISPENSER. (0.4% pyrethrins + 3% DDT + 5% cyclohexanone + 5% hydrocarbon oil in Freon; finished item; QM #51-I-159.)</p> <p>b. INSECTICIDE, LIQUID, FINISHED SPRAY. (1% DDT, 2½% thanite in refined kerosene; finished item; QM #51-I-169.)</p> <p>c. INSECTICIDE, SPRAY, DDT, RESIDUAL EFFECT. (5% DDT in refined kerosene with auxiliary solvent; QM #51-I-305.)</p> <p>d. INSECTICIDE, DDT, EMULSION CONCENTRATE. (25% DDT, 10% Triton X-100 + 65% xylene; stock mixture; QM #51-I-156.)</p>	<p>Spray 4 sec. per 1,000 cubic feet of space by releasing into the air of inclosure. Not necessary to spray insects directly since it acts like a gas. Effectiveness continues 2 to 4 hours after spraying.</p> <p>General utility spray applied with ordinary flit-gun type hand sprayer. This insecticide should be sprayed <i>directly</i> on the insects.</p> <p>Coarse spray (but not enough for run-off) on surfaces where flies and mosquitoes rest (1 qt per 250 sq ft). Apply to screens with a paint brush. One application usually remains effective against flies and mosquitoes in treated buildings for 3 or more months. Highly effective for long-term control in camp or garrison and native habitations. Mix 1 part concentrate with 4 parts of water and apply as for residual spray. Use only for flies and mosquitoes when specially required and authorized.</p>
	2. Out-of-doors, by spraying from aircraft.	a. 5 to 10% DDT in oil solution.	Two or more quarts of 5 percent DDT per acre will greatly reduce adult mosquito and fly population and control mosquito larvae up to a week or longer.
	3. Out-of-doors, by ground dispersal equipment.	<p>a. 5% DDT in kerosene, or oil</p> <p>b. INSECTICIDE, AEROSOL, 1-LB DISPENSER (QM #51-I-159).</p>	<p>Use hand or power spraying equipment with proper nozzle aperture. Atomize 1 or more quarts per acre for temporary control. Use 5 to 10 gallons per acre for longer periods of control. Around a clearing, apply spray on vegetation in a 50-foot or wider band encircling area to form a <i>barrier</i>.</p> <p>Attach an aerosol dispenser to a stick and spray (bomb horizontal) 6 inches from ground. One bomb per acre will control mosquitoes in jungle area for about 12 hours. Useful for temporary mosquito control in bivouac areas.</p>
	4. Control of flies in latrines.	a. INSECTICIDE, SPRAY, DDT, RESIDUAL EFFECT (QM #51-I-305) or 5% DDT in other oil solvents.	Apply twice a week evenly over pit contents at the rate of 2 ounces per latrine box hole (¼ oz per sq ft). In addition, spray walls of the pit, inside and outside of latrine box, and walls, ceiling, and screens of enclosure. Controls breeding primarily by lethal action on newly emerged adults.

DDT IN INSECT CONTROL—Continued

Insect to be controlled	Place of treatment	DDT Insecticide	Amount and method used
A. FLY AND MOSQUITO ADULTS—Continued	4. Control of flies in latrines—Continued	b. LARVICIDE, DDT, POWDER, DUSTING; 10% micronized DDT in talc; (QM #51-L-122) or other DDT powders.	Apply 2 ounces of the 10 percent dust per latrine hole twice a week. Also, apply residual spray to the rest of the latrine as directed above.
B. MOSQUITO LARVAE.	1. Swamps, pools, ruts, receptacles around dwellings, and other breeding sites.	a. 1 to 5% DDT in kerosene, Diesel, fuel, or crankcase oil. Mix locally. b. LARVICIDE, DDT, POWDER, DUSTING. (QM #51-L-122.) c. INSECTICIDE, DDT, EMULSION CONCENTRATE. (QM 51-I-156.) d. 5-10% DDT oil solutions.	For a 1 percent solution, add 2 pounds of DDT per 25 gallons of oil. Use 10 quarts of 1 percent DDT per acre of water surface with hand or power sprayers for a dose of 0.2 pound of DDT per acre. Dilute 10 percent powder with 4 to 9 parts of any dry dust diluent for application with hand rotary duster at the rate of 0.2 pound per acre. For hand casting, mix with 50 parts of diluent. Dilute 1 part concentrate with 24 parts water to make 1 percent DDT emulsion. Use 10 quarts per acre. Spray from aircraft at rate of 0.2 or more pound of DDT per acre.
C. LICE	1. On body and clothing.	a. DDT POWDER. (10% DDT in pyrophyllite or other inert dusts.) 2-ounce cans, QM #51-I-173; bulk, QM #51-I-180.	<i>Group delousing.</i> Thoroughly dust between inside garment and skin by applying dust gun at all openings of clothing. Apply from 1.0 to 1.5 ounce per individual, using hand dusters or power dusters. <i>Individual treatment.</i> Apply powder from sifter-top can over the entire inner surface of underwear and treat seams on the inside of shirt and trousers; use $\frac{1}{2}$ to 1 ounce powder.
	2. Body	a. INSECTICIDE, SPRAY, DELOUSING. (68% benzyl benzoate+12% benzocaine+6% DDT+14% Tween-80. QM #51-I-310.)	Dilute 1 part of the concentrate with 5 parts of water and spray hairy parts of body with about 20 cc of liquid. Protect eyes during application.
	3. Clothing impregnation.	a. INSECTICIDE, DDT, EMULSION CONCENTRATE. (25% DDT, 10% Triton X-100+65% xylene; QM #51-I-156.)	Dilute to 2 percent DDT with water (1 part concentrate, 11 parts water). Dip underwear in prepared solution. Ordinary laundry facilities could be used. Tongs should be provided for dipping underwear to avoid placing hands in solution. Use 1 quart per suit underwear. Two percent of dry weight of garment should be DDT. Renders garments louseproof through 6 to 8 launderings.

DDT IN INSECT CONTROL—Continued

Insect to be controlled	Place of treatment	DDT insecticide	Amount and method used
D. FLEAS-----	1. Rooms and rat burrows.	a. INSECTICIDE, SPRAY, DDT, RESIDUAL EFFECT. (5% DDT in kerosene; QM #51-I-305.)	One gallon per 1,000 square feet will give good results. In rooms apply to floor and lower wall. Heavier dosage required for earthen floors.
	2. On body, clothing, animal pets, in rooms and burrows.	a. DDT POWDER (10% in pyrophyllite; QM #51-I-180 or QM #51-I-173) on body, clothing and animal pets. For rooms and rat burrows, use Larvicide, DDT, powder, dusting (QM #51-L-122).	Light application to floors, burrows, and all surfaces and places to be treated. For group disinfection, use hand dusters or power dusters with same technique as for group delousing. Toxic to animal by licking coat. Application to back of animal's neck will clear up average infestation.
E. BEDBUGS-----	1. Enclosed spaces, beds, and mattresses.	a. INSECTICIDE, SPRAY, DDT, RESIDUAL EFFECT. (5% DDT in kerosene; QM #51-I-305.)	Spray mattresses, beds, and walls thoroughly. Give particular attention to springs and joints of beds and to crevices in walls. Thorough treatment eradicates all bedbugs and prevents reinfestation for over 6 months.
F. ROACHES-----	1. Enclosed spaces, under serving tables (including legs); sinks; along mopboards; into cracks and crevices; along border of ceiling and wainscoting; and in general, all runways and hiding places of roaches.	a. INSECTICIDE, SPRAY, DDT, RESIDUAL EFFECT. (5% DDT in kerosene; QM #51-I-305.)	Apply with sprayer or paint brush to form a film over surface. Reapply every month, or as local experience indicates.
		b. DDT POWDER. (10% DDT in talc; QM #51-L-122.)	Apply by hand duster with particular reference to cracks, crevices, and behind objects. Reapply as local experience indicates.
G. ANTS-----	1. Nests and runways.	a. DDT POWDER. (10% DDT in talc; QM #51-L-122.)	Dust is applied in a 3-inch-wide strip encircling the nest; over the nest; and across or along the ants' runways.
		b. INSECTICIDE, SPRAY, DDT, RESIDUAL EFFECT. (5% DDT in kerosene; QM #51-I-305.)	Spraying of runways and a thorough wetting of the ants' nests is very effective. On grass lawns, spray may cause "burning," making use of 10 percent DDT powder preferable.

Precautions: Avoid contamination of skin and clothing by oil solutions of DDT. Remove soiled garments and wash contaminated skin. Kerosene alone will cause skin irritation. Coveralls and rubberized gloves should be worn when mixing DDT solutions. Wear suitable respirator when applying DDT residual spray for prolonged periods in closed spaces. Avoid contamination of food. In mess halls, cover food, utensils, and table tops when spraying or dusting with DDT. Observe appropriate fire precautions when spraying DDT solutions. Air out treated rooms before reoccupation. Do not use emulsion concentrate in tightly closed structures, such as latrines, because of fire hazard from xylene fumes.